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EFFECT OF MODIFIED COPING DESIGN ON FRACTURE RESISTANCE OF ZIRCONIA CROWN

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Abstract:

***Aim of the study*:** To determine the effect of modified coping designs on the fracture resistance of zirconia crowns.

Materials and methods: Extracted human maxillary first premolar teeth were prepared to receive all-ceramic zirconia crown. Teeth were divided into two main groups according to the coping design. Group (I) (n=7) with Conventional zirconia coping extends to the finish line of the preparation. Group (II) (n=7) with cut-back zirconia coping **2** mm short from the finish line buccally. All specimens were veneered by the traditional hand-layering technique. Crowns were cemented by self-adhesive resin cement. Then, subjected to artificial aging; thermal cycling and cyclic loading before they were loaded in a universal testing machine for fracture resistance. Data were analyzed with Student's t-test.

Results: There was no significant difference in the mean fracture load values between conventional (477.71 ±28.13 N) and cut-back coping designs (473.29 ±35.22 N).

Conclusion: Modifications in coping design didn't improve the fracture resistance of zirconia crowns.

Keywords: zirconia, coping design, cut-back

Introduction

With the increasing demand for esthetics, possessing white teeth in a beautiful smile and mimicking natural teeth appearance, ceramic materials are the best. They have good properties such as hardness, chemical resistance, esthetics, compression resistance and biocompatibility. But brittleness and low tensile strength represent the major weak points which should be improved.[1] One of the strengthened ceramic materials was the zirconium dioxide material. Yttria-stabilized tetragonal zirconia polycrystals (Y-TZP) is known to be the strongest ceramic material available in the dental field.

Zirconia frameworks are veneered with porcelain to give the appearance of natural teeth, as using zirconia alone does not meet the high esthetic demands expected for all-ceramic restorations. Veneer chipping or cracking is the most common cause of technical failure in zirconia restorations. The interface between zirconia core and the veneering material is the origin of this failure.[2] Adequate coping design, proper veneering ceramic support and thickness are factors implicated in the ceramic survival.

The purpose of this study is to determine the effect of modifications in the coping design on the fracture resistance of zirconia all-ceramic crowns. The null hypothesis of this study is that modifications in the coping design would not affect the fracture resistance zirconia crowns.

MATERIAL AND METHODS

Specimens preparation

Twenty-eight human first maxillary premolars extracted for mobility or orthodontic reasons were selected for this study. They were mounted in acrylic resin blocks to facilitate their preparation, impression making and pouring. Guiding grooves were used to verify the amount of cutting. To be sure that all prepared teeth have the same degree of tapering, preparation was completed by using the "Milling unit BF 2" (bredent GmbH & Co.KG, Germany). The finally prepared tooth had the following criteria; 1.5 mm occlusal reduction at central fissure, 2 mm cuspal reduction and 1 mm chamfer finish line placed 0.5 mm occlusal to CEJ.

Fabrication of zirconia copings

Each tooth was duplicated into stone die for scanning and veneering. Each stone die was placed inside a stone block and fixed in the standard holder of the scanner to start arch scanning then; preparation scan contour design was done. The core thickness was set to be 0.5 mm at the circumference for all specimens. Two coping designs were made by the CAD/CAM program according to finish line placement. The first was a conventional zirconia coping which extends to the finish line of the preparation. The second zirconia coping was a cut-back design of 2 mm short from the finish line buccally while reaching the finish line palatally (Figure 1). These data files were sent to the milling machine to mill the copings. Then, all copings were sintered in the sintering furnace.

Build-up veneering ceramic by Layering technique

Zirconia copings were sandblasted with 50 µm alumina sand under pressure of 29 psi. Porcelain separator was applied to the margin area of the dies to prevent stickiness of the porcelain. Body Porcelain CZR A3 B (Kuraray Noritake Dental Inc., Tokyo, Japan) was applied to the margin area of the dies and proceeded to all surfaces according to the desired dimensions to create the crown form. Then, they were baked according to the manufacturer baking schedule. The occlusal third of the buccal surface and the proximal contact areas were cut back to allow for enamel porcelain application and baked again in the furnace. Crowns were measured by a caliper and thickness was adjusted by careful grinding then, they were glazed.

Cementation

The fitting surfaces of zirconia crowns of all groups were sandblasted according to manufacturer instructions with 50 µm alumina at a pressure of 60 psi (0.4 MPa) from 10 mm distance. Then, Maxcem Elite Chroma self-adhesive resin cement (Kerr, USA) was used for cementation of crowns to their corresponding prepared teeth.

Artificial aging protocol

All zirconia crowns were subjected to thermal cycling for 15,000 cycles at temperatures alternating between 5 and 55 ºC. The dwelling time in each bath was 3 minutes while the transfer time from one bath to the other was also 3 minutes. The specimens then underwent dynamic cyclic loading for 250,000 cycles in a water bath. A load of 100-200 N was applied occlusally to the central fossa of the specimens at a frequency of 1.7 Hz. Specimens without fracture after aging were mounted on a universal testing machine for fracture resistance testing. A stainless steel ball of 6 mm diameter was used at a cross-head speed of 0.5 mm/min until fracture.

Statistical analysis of data:

Data were analyzed using the computer program SPSS (Statistical package for social science) version 23.0 to obtain descriptive statistics in the form of Mean ± Standard deviation (SD). In the statistical comparison between the different groups, the significance of difference was tested using Student's *t*-test. A P value <0.05 was considered statistically significant.

RESULTS

The mean fracture load values were; 477.71 ±28.13 N for conventional coping design group and 473.29 ±35.22 N for cut-back coping design group. Student t-test revealed no significant difference in the mean fracture load values between conventional and cut-back coping designs (P = 0.79). Table (1)

DISCUSSION

As there was no statistically significant difference in the mean fracture load values between conventional and cut-back coping designs, the hypothesis of this study was accepted. In this study, customization of zirconia frameworks was derived from the experience with porcelain fused-to-metal crowns. A porcelain shoulder was used to overcome black line along the crown margins, improving esthetics and getting better marginal adaptation. Similarly, the porcelain shoulder has been introduced for use with zirconia crowns leading to further improvement of esthetics. A thicker veneering ceramic at the cervical area would enhance the translucency and avoid the white line from the core material along the crown margins.[3]

In a study done by ***Fotek***,[4] he investigated fracture resistance of zirconia restorations with three different coping designs. He used a conventional coping design, a cut-back design to the axial cervical line angle and a cut-back design to the middle of the buccal wall. It was concluded that there was no difference between the first two coping designs while, the third design decreased the fracture load resistance. This could be because of the large cut-back area that didn't support the veneering ceramics. In another study done by ***Eisenburger et al.***[5] they investigated conventional and porcelain shoulder (**1** mm) zirconia cores veneered with layering and press-over techniques. They found no significant differences between all groups.

The differences between results obtained in the above studies could be due to different zirconia framework and veneering ceramic combinations. Some variations in the mechanical testing parameters and using CoCr abutment rather than natural teeth may also alter the results. Specimens without aging procedures either thermal cycling or cyclic loading and not exposed to an aqueous environment as in the mouth may give higher values.[6]

CONCLUSION

Within the limitations of this in-vitro study, the following conclusions can be suggested:

1- Modifications in the coping design either conventional or cut-back didn't affect fracture load values of zirconia crowns.

2- There was no significant difference in the mean fracture load values between conventional and cut-back coping designs.

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TABLES

Table (1): Comparison between Conventional and Cut-back coping designs as regard the fracture load.

Coping design				
Conventional		Cut-back		*P*
Mean	±SD	Mean	±SD	
477.71	28.13	473.29	35.22	**0.79**

Data expressed as mean ±SD

SD: standard deviation ***P***: Probability *: significance <0.05

FIGURES

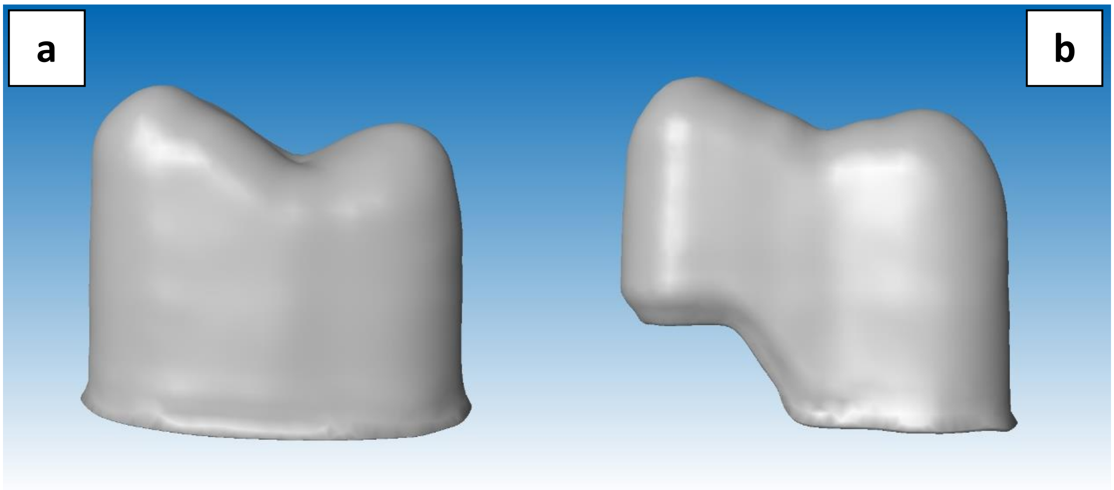

Figure 1: Two coping designs; (a) Conventional (b) Cut-back.